Sea-Based Aviation National Naval Responsibility (SBA NNR)
- Structures and Materials -

Overview and Roll-out

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National Naval Responsibility (NNR) Purpose

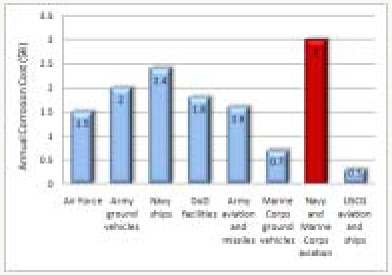
To allow ONR to maintain the health/currency/technical superiority of identified Navy-unique S&T in order that:

- A robust U.S. research capability to work on long term S&T problems of interest to the Department of the Navy is sustained;
- An adequate pipeline of new scientists and engineers in disciplines of unique Navy importance is maintained; and
- ONR can continue to provide the S&T products necessary to ensure future superiority in integrated naval warfare.

Sea Based Aviation Operations and Environment

- **Dynamic Interface: Highly coupled relationship between the ship and aircraft**
  - Moving deck: pitch / roll / yaw / heave / sway / surge
  - Turbulent air wake
  - Small decks; obstructions
- **High Structural Loading**
  - Rigors of shipboard launch and recovery
  - High sink rates
- **Corrosion**
  - Corrosion degradation much more aggressive and damaging than even harsh land-based conditions
  - Compounded by reduced damage tolerance due to high launch and recovery impact loads
- **Deck Operations**
  - Close proximity of other aircraft and personnel
  - Safe handling in rough seas
- **Geometric Constraints & Spotting**
  - Compact aircraft
  - Wing/Rotor folds
- **Shipboard Maintenance**
  - Low physical footprints
  - Maintenance accessible designs
  - Limited spares

What unique or highly Naval-driven science and technology is needed?



Sea-based Aviation (SBA) National Naval Responsibility (NNR) Objective

- The sea-based aviation is both unique and complex and inherently dangerous
- Navy places great emphasis on S&T to maintain Naval superiority
- *Many S&T areas are unique to the Navy

ONR must ensure leadership in sea-based aviation through research, recruitment and education to maintain an adequate talent base and to sustain critical infrastructure

** Weapon, sensors, and ship design are outside the SBA NNR scope*

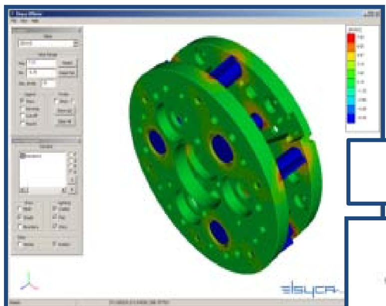
Sea-Based Aviation NNR Program Focused Approach

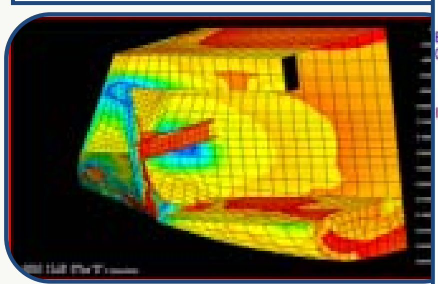
Overall Challenge	Focused Technical Challenge Areas	Focused Investments
Maintain the health, currency, and technical superiority of Sea-based Aviation S&T.	**Aero / Autonomy/Ship Interface**	• Virtual Dynamic Interface (VDI) • Advanced Manned/Unmanned HQ & Control for Naval Operations • Improved Low-Speed Aerodynamics for Fixed-Wing Aircraft Launch & Recovery • Autonomous deck operations • Enhanced FW V/STOL Operations Corrosion protection, detection, and mitigation.
	Structures	• Structural Mode Characterization • High-Loading, Lightweight Structural Materials • Advanced Structural Concepts • Materials Degradation/Corrosion • Structural Protection /Maintenance
	Propulsion	• Energy-Efficient Processes and Subsystems • Turbomachinery and Drive Systems with Enhanced Maintainability • Jet Noise Reduction for TACAIR • Hot-Section Materials and Coatings • Small UAV Propulsion

Today: More Complexity, Less Durability

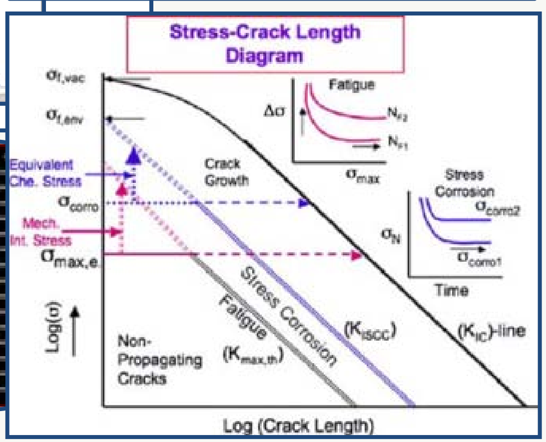
- Degradation/corrosion of airframes is the largest maintainability degrader
    - Primarily designed for immediate mechanical / structural response
    - Degradation of properties over the lifecycle is an afterthought / sustainment
- Lack true failure mechanism understanding of load path effects, crack growth, non-isotropic
    - Overdesign, new material limits, costly life extensions, unexpected failures

Corrosion rates on complex structures





Modified Kitagawa Diagram



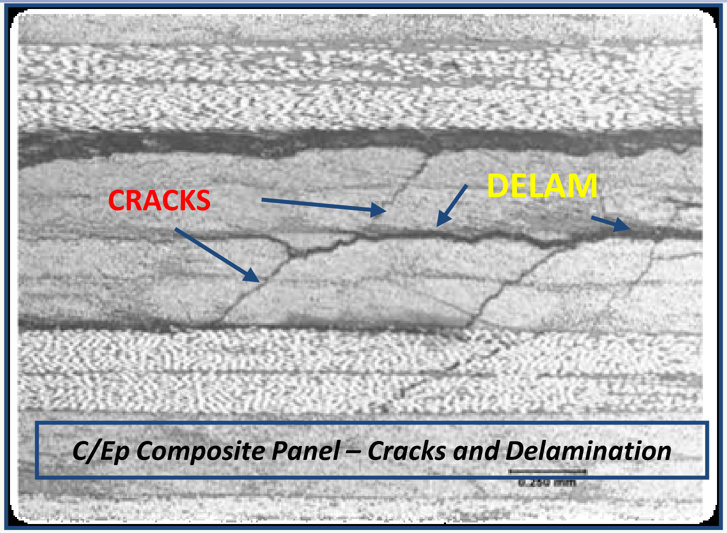
Future: Advanced Airframes

- Full Airframe Risk and Reliability
    - Multi-material, Predictive
    - Damage Accumulation Decisions
    - Sea-based Environment Impacts
- High-Load/Light Weight Materials
    - Extend operational service life
    - Increase durability, range
- Durable Aircraft and Advanced Concepts

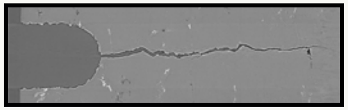
Technology Impact

Warfighter Payoff:

- Integrated design analysis /prognosis – optimize airframe structural properties and match material selection to operational requirements
- Light weight, flexible, and degradation resistant advanced materials can improve fatigue life, reduce risk of catastrophic failure and facilitate control of weight/balance
- Model complex behaviors/interactions – predict risk, probability and mechanism of failure; forecast lifetime performance



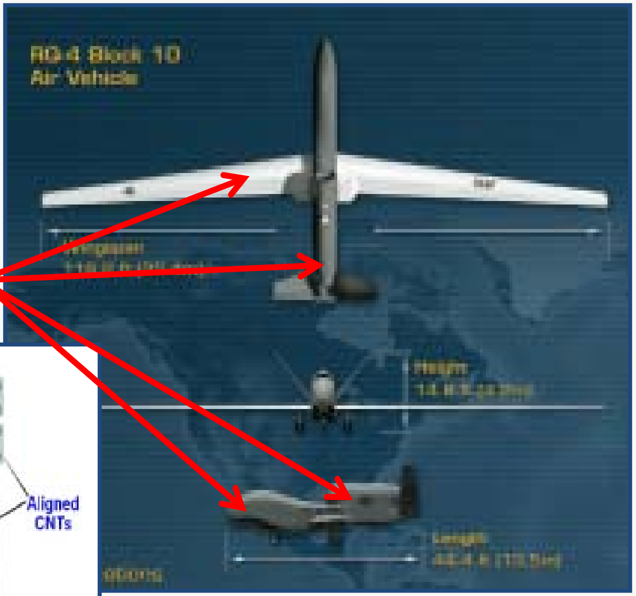
C/Ep Composite Panel – Cracks and Delamination

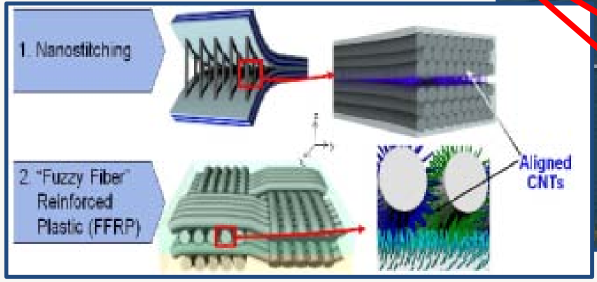


Business Case:

- Increased Availability/Readiness
- Reduced Sustainment Requirements
- Fatigue/Loads Life Enhancement
- Reduced Weight and Improved Range
- Design tools/Standard Practices

Composite Applications

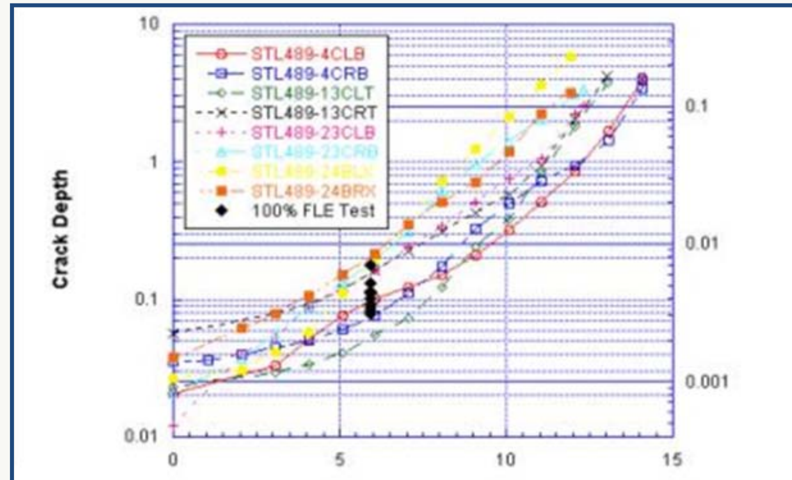




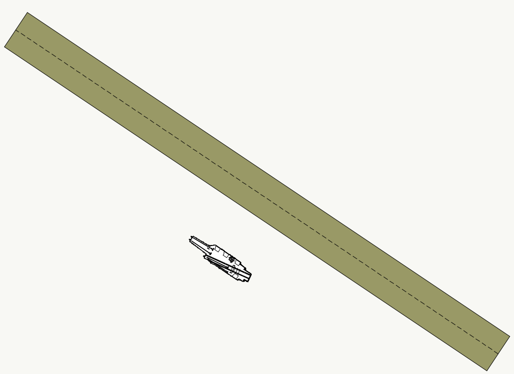
Challenges

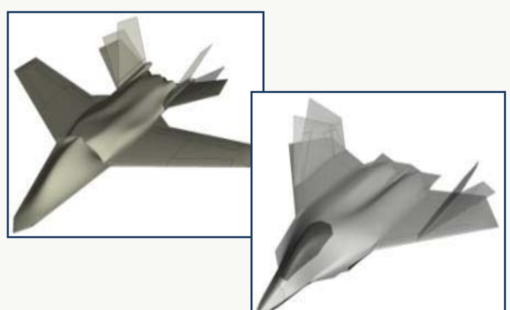
Technical Challenges:

- Multi-material Analyses – Predict fatigue and fracture
  - Structural damage occurs over multiple length and time scales
- Integrating Structural Response, Lifing, and Degradation Effects
- Multi-Functional Materials Research
- New Material Characterization, Interactions
- More Complex Designs, Reduced Options
- Multi-disciplinary Expertise



Risk & Reliability Quantification





High Maneuverability and Load Reduction - Morphing

Other Challenges:

- Not Flashy – Perception of “Settled”
- Acquisition/Widget Focused
- Not Platform/Hardware Specific
- Materials Underlying Enabler
  - Afterthought in Design
- Good 6.3 Ideas – Lack Support
- COTS , Acquisition Process vs. Military Durability

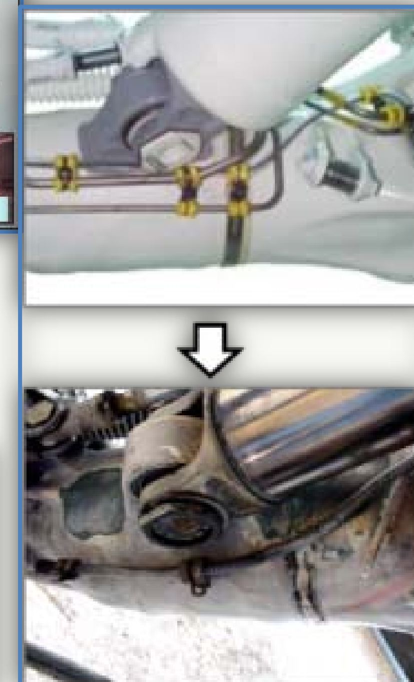
Introduction

- Goal: Sea Based Aviation NNR program in the areas of Structures and Materials
  - Other major areas are Aero and Propulsion
    - Conducting parallel technical focus area programs
- SBA NNR officially begins FY14
  - FY13 can be considered a transition year
  - Continuing/new projects should align to SBA NNR roadmaps
- Focus is on Basic and Applied Research
  - Leverage into planned 6.3 transitions

Structures and Materials Focus Area

Airframe Structures

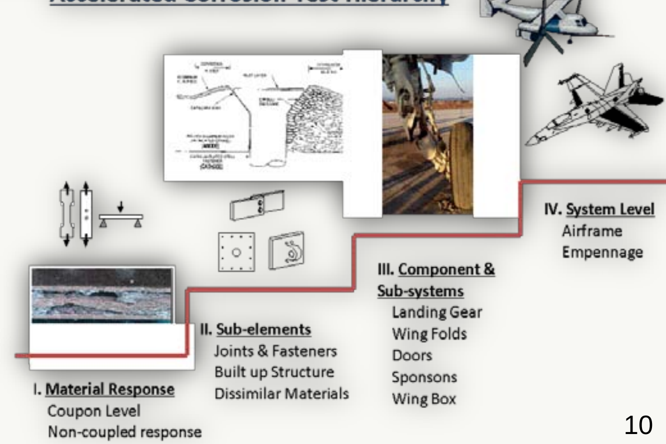
Design, materials selection, fabrication, inspection and maintenance related to air-vehicle structures.



Technical Challenges

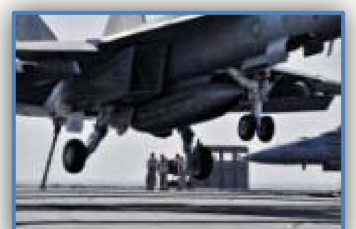
High Loads, Weight Reduction;
Advanced Composites, Shipboard Repair,
Material Coatings, Corrosion,
Structural Life Models.

Accelerated Corrosion Test Hierarchy

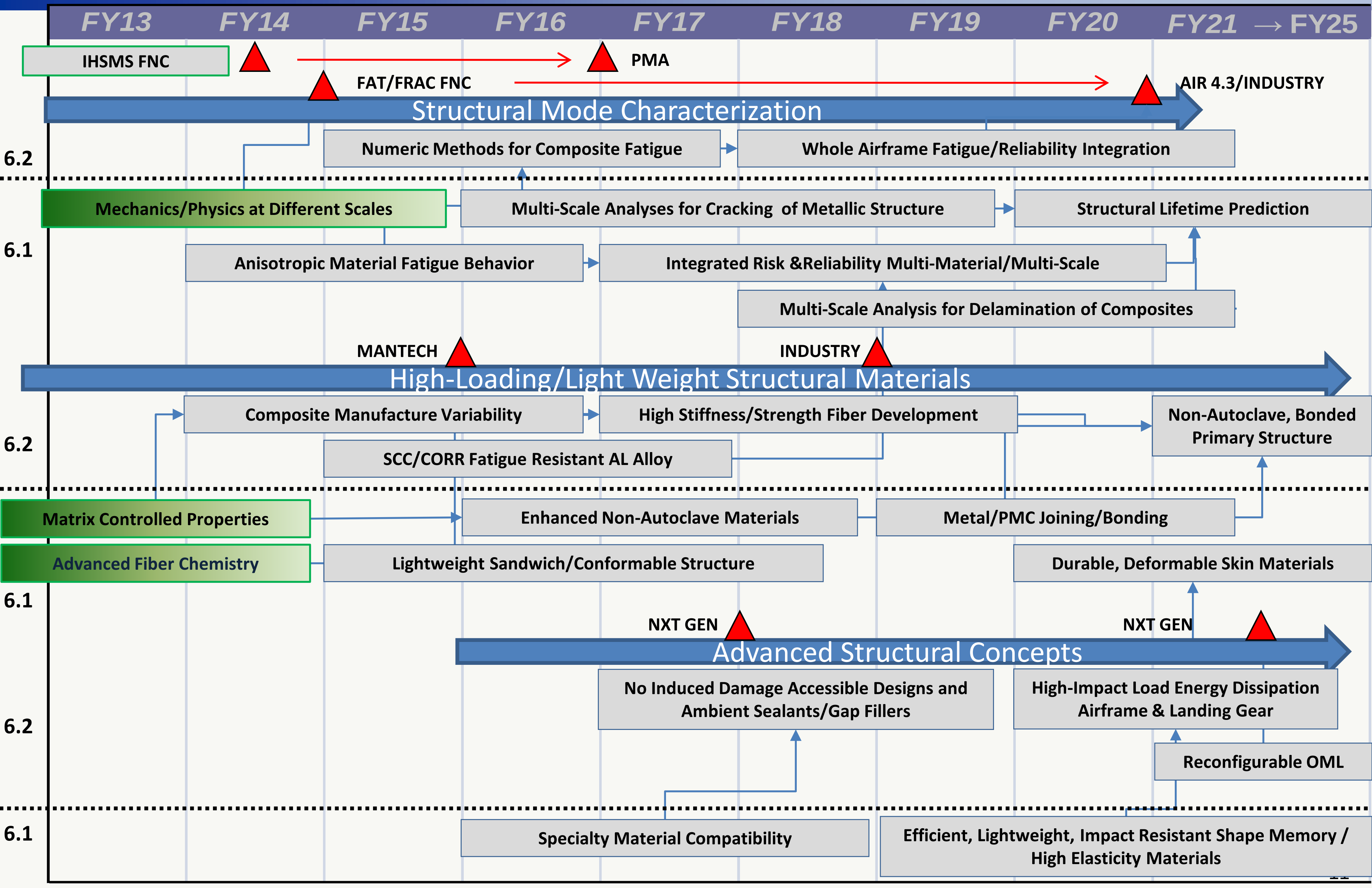


Focus Areas

- **Structural Mode Characterization**
- **High-Loading, Lightweight Structural Materials**
- **Advanced Structural Concepts**
- **Materials Degradation/Corrosion**
- **Structural Protection /Maintenance**



Advanced Airframe Products



Structures and Materials
Advanced Airframe Products

Structural Mode Characterization – Improved understanding of structural behaviors

Integrated design approaches to high-fidelity airframe life management:

- Fatigue & Fracture – Understanding & modeling of physics with length and complexity scaling
- Damage Characterization – Understanding & modeling progression & residual strength prediction in composites
- Multi-scale analysis – Analytical & computational methods for damage evolution
- Fatigue Enhancements - Modeling of cold working, peening, etc. in metallic structures to quantify life improvements
- Environmental Effects – Incorporating environmental effects into strength, prognosis, and after damage event remaining life
- Bonded Joints – Understanding damage propagation in bonded joints under static and fatigue loading
- Verification & Validation – Structural models used for certification & life prediction
- Risk & Reliability – Quantifying risk & reliability for structural components & integrating whole airframe analysis

High-Loading, Lightweight Structural Materials – Optimize airframe material properties

Making advanced composites more affordable, reliable alternatives:

- Manufacturing variability – Reducing defects in joints and bonds, reducing voids and porosity
- Damage response – Optimizing for improved fatigue/delamination resistance and thermal/moisture damage
- Primary structure – Transverse load path strengthening, crack arrest, out of autoclave resins, matrix/fiber improvements
- Certification – Testing, analysis & methodology improvements for rapid transition

Improve performance and speed transition of advanced metallic structures

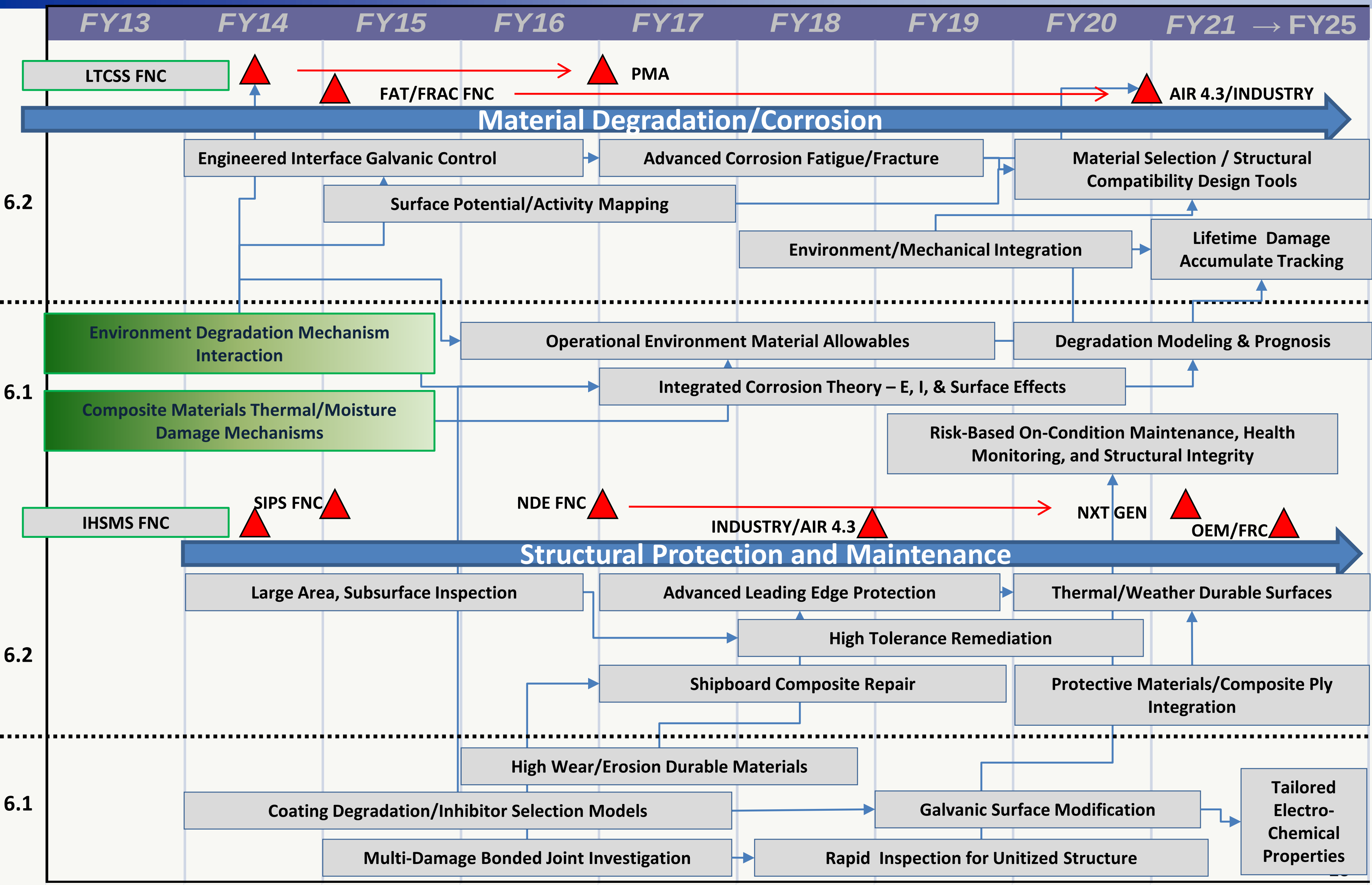
- SCC/Corrosion Fatigue – Improved aerospace aluminum, titanium & high-strength steel alloys
- Material Properties Improvements – Higher strength, lighter weight, lower cost, easier fabrication aerospace alloys
- Property Optimization – Improve metal/composite joining, new material characterization, methods for certification & transition
- Lightweight, Conformable Core – Metal foams, composite sandwich, failure mapping

Advanced Structural Concepts – Materials tailored structural responses

Implementation of novel/next gen airframe concepts

- Adaptive structural response – On-demand load response, impulse events, advanced landing gear, reconfigurable structure
- Specialty material systems – Adaptable OML, storage stability and application methods, modeling of interactions

Durable Aircraft Products



Structures and Materials
Durable Aircraft Products

Materials Degradation/Corrosion – Physical/Chemical interactions of operational exposures

Designing, characterizing and optimizing materials for sea-based durability

- Failure mechanisms – Multi-mode degradation mechanisms , complex environments, thermodynamic phase stability
- Multi-scale modeling – Material inputs for coatings, processes, and mechanical/structural interactions in realistic environments
- Surface effects – Chemical potential, electrochemical activity, active/passive compounds, ionic nature, physical morphology
- Environmental/mechanical – Integrate material property degradation and structural/mechanical behavior analyses
- Galvanic management – Potential modification, interface isolation, current control/directional flow characterization
- Materials allowables – Material selection with degradation prediction, engineered interfaces for tailored corrosion response,
- Design tools – Materials selection, galvanic "stress" in complex assemblies, mixed degradation modes, validation processes
- On-condition – Combined integrity, reliability, and maintenance actions based on materials/loads damage accumulation
- Fatigue & Fracture – Integrating degradation initiated mechanical damage and environmental effects on damage propagation
- Testing & Characterization – Measurements and accelerated evaluation methods with operational exposure correlation

Structural Protection /Maintenance – Coatings, industrial processes, NDI, & repair methods

Improve material coatings, portable inspection, and structural repair aboard ship

- Composite bond-line inspection – Rapid inspections to cover large, unitized area for kissing bonds, voids, and bondline strength
- Sub-surface/multi-layer NDE – Through OML, compatible with mixed materials, bond/fastener line and faying surface
- Erosion/leading edge – Combined rain, particle/FOD, and thermal wear protection, adhesion/flex and thermal stability
- Material coatings – Effects of dissimilar material/coatings and chemistry, understanding coating damage and inhibitor functions
- Shipboard maintenance – Storage stability and high-moisture cure chemistry, application/delivery methods for sea-basing,
- Surface modification – Galvanic matching of noble/anodic surfaces, composite ply inherent protection, C-fiber modifications
- Composite repair – In-situ/shipboard repair with load bearing capability and non-autoclave/non-oven cure mechanisms
- Specialty coatings – Compatibility analysis and impact prediction, operational fluids – de-icing/cleaning, material effects

- Timeline for Structures and Materials Sub-Thrust
  - Beginning Government Fiscal Year 2014 (FY14)
  - 6.1/6.2 Funding – Basic and Applied Research
  - Partnerships with DoN Laboratories encouraged (e.g. NAWC, NRL)
  - Program fact sheet – ONR website – July 2012
  - Call for white papers via Special Notice – announcement in AUG 2012
  - Outreach workshop in SEP 2012
  - Invitation to submit full proposal for FY14 efforts in DEC 2012
  - Proposals due FEB 2013
  - Selections made MAY 2013
  - Awards made SEP 2013
  - Validate roadmaps – annual update process

Questions / Comments

Bill C Nickerson, Program Officer (Detailee)

SBA NNR Structures and Materials, 6.1/6.2 Lead

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Naval Air Warfare and Weapons Department (Code 35)

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Glossary

6.1	Department of Defense Budget Activity – Basic Research
6.2	Department of Defense Budget Activity – Applied Research
ASW	Anti-submarine Warfare
CBD	Commerce Business Daily
CMC	Ceramic Matrix Composite
FADEC	Full Authority Digital Engine Control
FNC	Future Naval Capability
FOD	Foreign Object Damage
FW	Fixed-wing aircraft
FY	Government Fiscal Year
GNC	Guidance, Control and Navigation
HQ	Hardware Qualification
IBR	Investment Baseline Review
INP	Innovative Naval Prototype
LTC	Low Temperature Combustion
NAVAIR	Naval Air Systems Command
NRL	Naval Research Laboratory
NNR	National Naval Responsibility
ONR	Office of Naval Research
PEO	Program Executive Office (T – Tactical Aircraft, A – Air ASW, Assault and Special Mission)
PMA	Program/Project Manager, Air (263 - Small Tactical Unmanned Aircraft System)
S&T	Science and Technology
SBA NNR	Sea-based Aviation National Naval Responsibility
TACAIR	Tactical Aircraft
TET	Turbine Engine Technologies
UAV	Unmanned Aerial Vehicle
VCE	Variable Cycle Engine
VDI	Virtual Dynamic Interface
V/STOL	Vertical/Short Take-off and Landing
WOD	Wind-over-deck